CLAIMS

1. A method of determining the presence or absence of one or more nonlinear impairments in a linear medium, comprising:

setting one or more pulse transmission parameter values;

applying a first sequence of one or more first transmit pulses to the medium for transmission through the medium under the one or more pulse transmission parameter values;

receiving from the medium a first sequence of one or more echo signals reflected from impairments in the medium in response to the first sequence of transmit pulses;

digitizing the echo signals for each transmit pulse of the first sequence of first transmit pulses to produce a set of digital values for each transmit pulse of the first sequence of first transmit pulses;

averaging the digital values for corresponding echo signals of the first sequence of echo signals to produce a first digitized set representing the average of the first sequence of echo signals;

changing the one or more pulse transmission parameter values;

applying a second sequence of one or more second transmit pulses to the medium for transmission through the medium under the one or more changed pulse transmission parameter values;

receiving from the medium a second sequence of one or more echo signals reflected from impairments in the medium in response to the second sequence of transmit pulses;

digitizing the echo signals for each transmit pulse of the second sequence of second transmit pulses to produce a set of digital values for each transmit pulse of the second sequence of second transmit pulses;

averaging the digital values for corresponding echo signals of the second sequence of echo signals to produce a second digitized set representing the average of the second sequence of echo signals;

combining the first and the second digitized sets to produce a residual digitized set; and

examining the residual digitized set for a residual pulse indicating the presence of one or more nonlinear impairments.

2. The method of claim 1 wherein combining includes:

choosing a scale factor S that is allowed to be equal to 1 or any other real number; and

multiplying each digital value of the first digitized set by S and subtracting each product from the corresponding digital value of the second digitized set to produce the corresponding digital value of the residual digitized set.

3. The method of claim 2 wherein the at least one pulse transmission parameter is selected from the group including an operating point at which the first and second transmit pulses are applied to the medium, a polarity at which the first and second transmit pulses are applied to the medium, and an amplitude at which the first and second transmit pulses are applied to the medium.

4. The method of claim 2 wherein the medium is a medium in the set consisting of a twisted pair transmission line and a coaxial transmission line.

5. The method of claim 2 wherein S is the ratio of the amplitude of the second pulses to the amplitude of the first pulses.

6. The method of claim 2 wherein the at least one pulse transmission parameter is an electrical bias establishing an operating point at which the first and second transmit pulses are applied to the medium.

7. The method of claim 6 whereby the electrical bias is applied by applying a dc current to the medium.

8. The method of claim 6 whereby the electrical bias is applied by applying a dc voltage across the medium.

9. The method of claim 8 whereby applying a dc voltage includes applying a voltage across a telephone channel from a telephone company central station.

10. The method of claim 9 further including placing a conducting element to the channel at a customer end to cause a dc current to be applied to the channel.

11. A method for differentiating at least one nonlinear impairment from any linear impairments present in an electrically conductive line, the method comprising:

performing a first measurement on the line by a time domain reflectometry apparatus to detect the presence of at least one nonlinear impairment in the line;

receiving a first data sequence in the first measurement, the first data sequence including echo signals reflected from impairments in the line, in which first echo signals reflected from at least one nonlinear impairment are not distinguishable from first echo signals reflected from any linear impairment in the line;

storing the first data sequence obtained in the first measurement;

altering the impedance of at least one nonlinear impairment in the line without altering the impedance of any linear impairment in the line;

performing a second measurement by the time domain reflectometry apparatus on the line;

receiving a second data sequence in the second measurement, the second data sequence including second echo signals reflected from the impairments in the line, in which second echo signals reflected from the at least one nonlinear impairment in the line have characteristics which are distinguishable from corresponding characteristics of

second echo signals reflected from the any linear impairment in the line, the characteristics resulting from altering the impedance;

storing the second data sequence obtained in the second measurement; and

combining the first data sequence and the second data sequence to distinguish echo signals reflected from the at least one nonlinear impairment in the line from any linear impairment in the line based on the characteristics.

12. The method of claim 11, each of the first and second measurements including coupling test pulses from the time domain reflectometry apparatus to the line, wherein the combining includes determining the ratio of the amplitudes of the test pulses in the first and second measurements, multiplying the amplitude of each of the echo signals of the second data sequence by the ratio, and, sequentially subtracting the amplitudes of the echo signals of the first data sequence from the corresponding amplitudes resulting from the multiplying in order to mutually cancel amplitudes of echo signals from any linear impairment in the line while leaving a non-cancelled amplitude identifying the at least one nonlinear impairment in the line.

13. The method of claim 12 whereby altering the nonlinear impedance includes controlling an operating point of the at least one nonlinear impairment about which the time domain reflectometry apparatus performs the first and second measurements.

14. The method of claim 13 whereby controlling the operating point of the nonlinear impairment includes electrically biasing the at least one nonlinear impedance.

15. The method of claim 14 whereby electrically biasing includes applying dc current to the line.

16. The method of claim 15 whereby applying a dc current to the line includes applying a dc voltage across the line.

17. The method of claim 16 whereby applying a dc voltage includes applying a dc voltage across a telephone line from a central telephone station.

18. The method of claim 16 whereby applying a dc voltage includes placing a resistor across the line at the central telephone station.

19. The method of claim 12 whereby controlling the operating point of the nonlinear impedance includes reversing the polarity of pulses provided by the time domain reflectometry apparatus between the first and the second measurements.

20. A time domain reflectometry apparatus, comprising:

a pulse amplifier with an output for producing sequences of transmit pulses for application to an electrically conductive line;

a switch circuit connected to the pulse amplifier output for controlling transmission parameters of the transmit pulses applied to the line;

a digitizer with an input for receiving echo signals reflected from impairments in the line in response to the sequences of transmit pulses;

storage connected to the digitizer for storing sets of digitized echo signals, a first set including at least one digitized echo signal representing an echo signal reflected from an impairment in the line in response to a first sequence of transmit pulses applied to the line under first transmission parameters and a second set including at least one digitized echo signal representing an echo signal reflected from an impairment in the line in response to a second sequence of transmit pulses applied to the line under second transmission parameters; and

an arithmetic unit connected to the storage for:

averaging amplitudes of the signals in the first set of digitized echo signals and magnitudes of the signals of the second set of digitized echo signals;

combining the average amplitudes of the signals of the first set of digitized echo signals with the average amplitudes of corresponding signals of the second set of digitized echo signals; and

distinguishing at least one nonlinear impairment in the line based upon the combination.

21. The apparatus of claim 20 wherein the arithmetic unit includes means for computing a first ratio of amplitudes of the transmit pulses in the first and second sequences, computing second ratios of the amplitudes of corresponding digitized echo signals in the first and the second sets of digitized echo signals, and distinguishing the at

least one nonlinear impairment when the first ratio is not equal to one of the second ratios.

22. The apparatus of claim 21 wherein the switch includes means for controlling an operating point at which the sequences of transmit pulses are applied to the line.

23. The apparatus of claim 22 wherein the means for controlling the operating point includes means for electrically biasing the line.

24. The apparatus of claim 23 wherein the means for electrically biasing includes means for applying a dc current in the line.

25. The apparatus of claim 23 wherein the means for electrically biasing includes means for applying a dc voltage across the line.

26. The apparatus of claim 25 wherein the line is a telephone line, the voltage applied from a telephone central station.

27. The apparatus of claim 26 the means for electrically biasing including a conducting element placed across the line during at least one of the sequences.

28. The apparatus of claim 22 wherein the switch includes means for reversing the polarity of the transmit pulses.

29. An apparatus for differentiating at least one nonlinear impairment from any linear impairments present in an electrically conductive line, the apparatus comprising:

a time domain reflectometry apparatus for performing a first measurement and a second measurement on the line to detect the presence of the at least one nonlinear impairment in the line;

a switch connected to the time domain reflectometry apparatus for altering the impedance of the at least one nonlinear impairment after the first measurement without altering the impedance of the any linear impairments;

storage for sequentially storing a first data sequence in the first measurement and a second data sequence in the second measurement, the first data sequence including echo signals reflected from impairments in the line, in which first echo signals reflected from at least one nonlinear impairment are not distinguishable from first echo signals reflected from any linear impairment in the line, the second data sequence including second echo signals reflected from the impairments in the line, in which second echo signals reflected from the at least one nonlinear impairment in the line have characteristics which are distinguishable from corresponding characteristics of second echo signals reflected from the any linear impairment in the line, the characteristics resulting from altering the impedance; and

a processor connected to the storage for combining the first data sequence and the second data sequence to distinguish echo signals reflected from the at least one nonlinear impairment in the line from any linear impairment in the line based on the characteristics.

30. The apparatus of claim 29 wherein each of the first and second measurements including coupling test pulses from the time domain reflectometry apparatus to the line, wherein the arithmetic unit includes means for determining the ratio of the amplitudes of the test pulses in the first and second measurements, multiplying the amplitude of each of the echo signals of the second data sequence by the ratio, and sequentially subtracting the amplitudes of the echo signals of the first data sequence from the corresponding amplitudes resulting from the multiplying in order to mutually cancel amplitudes of echo signals from any linear impairment in the line while leaving a non-cancelled amplitude identifying the at least one nonlinear impairment in the line.

31. The apparatus of claim 30 wherein the switch includes means for controlling the operating point of the nonlinear impairments about which the time domain reflectometry apparatus performs the measurement.

32. The apparatus of claim 31 wherein the means for controlling the operating point includes means for electrically biasing the line.

33. The apparatus of claim 32 wherein the means for electrically biasing includes means for applying dc current to the line.

34. The apparatus of claim 33 wherein the means for applying dc current to the line includes means for applying a voltage across the line.

35. The apparatus of claim 34 wherein the line is a telephone line and the means for applying the voltage is in a central telephone station.

36. The apparatus of claim 34 wherein the means for applying a voltage across the line includes a conducting element placed across the line.

37. The method of claim 31 whereby the means for controlling the operating point includes means for reversing the polarity of pulses provided by the time domain reflectometry apparatus between the first and the second measurements.

38. A method of determining the presence or absence of one or more nonlinear impairments in a linear medium, comprising:

setting one or more pulse transmission parameter values;

applying a first sequence of one or more first transmit pulses to the medium for transmission through the medium under the one or more pulse transmission parameter values;

receiving from the medium a first sequence of one or more echo signals reflected from impairments in the medium in response to the first sequence of transmit pulses;

digitizing the echo signals for each transmit pulse of the first sequence of first transmit pulses to produce a set of digital values for each transmit pulse of the first sequence of first transmit pulses;

averaging the digital values for corresponding echo signals of the first sequence of echo signals to produce a first digitized set representing the average of the first sequence of echo signals;

changing the one or more pulse transmission parameter values;

applying a second sequence of one or more second transmit pulses to the medium for transmission through the medium under the one or more changed pulse transmission parameter values;

receiving from the medium a second sequence of one or more echo signals reflected from impairments in the medium in response to the second sequence of transmit pulses;

digitizing the echo signals for each transmit pulse of the second sequence of second transmit pulses to produce a set of digital values for each transmit pulse of the second sequence of second transmit pulses;

averaging the digital values for corresponding echo signals of the second sequence of echo signals to produce a second digitized set representing the average of the second sequence of echo signals;

combining the first and the second digitized sets to produce a residual digitized set; and

determining the distance to at least one of the one or more nonlinear impairments based upon the location of displacements in the residual digitized set.